OMI OPERATIONS
STATUS

Jacques Claas
Instrument Operations Team
KNMI
The Netherlands

MOWG
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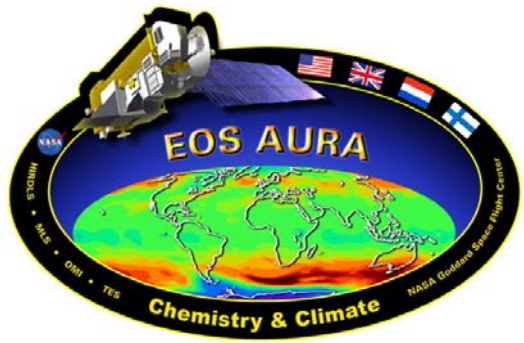
Boulder

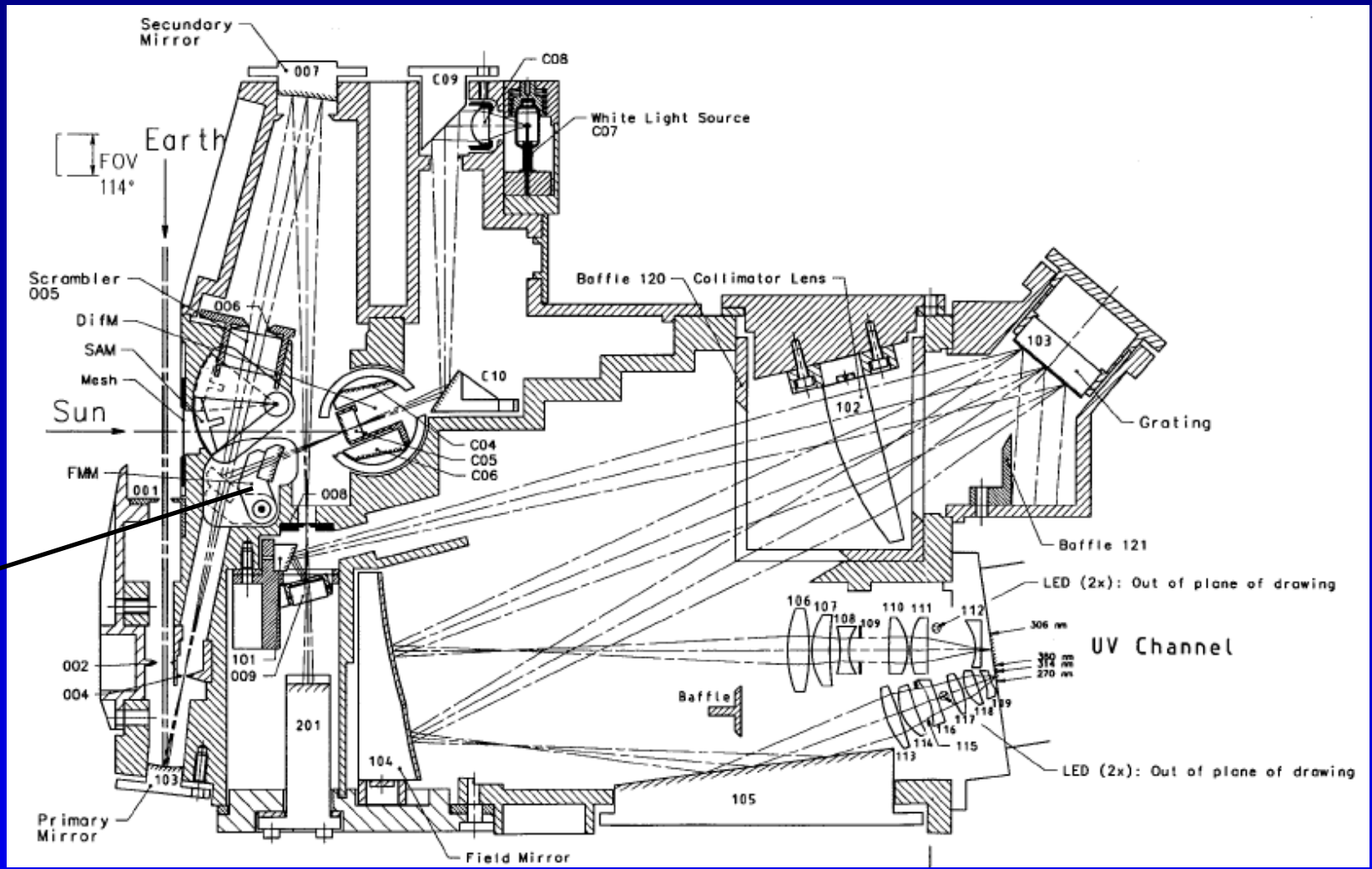


Content of Presentation

- Folding Mirror Mechanism (FMM) anomaly
- Operations status and outlook

FMM anomaly: purpose of FMM

The FMM is a stepper motor. It is needed when performing calibration measurements



FMM

Design drawing of the OMI optical bench

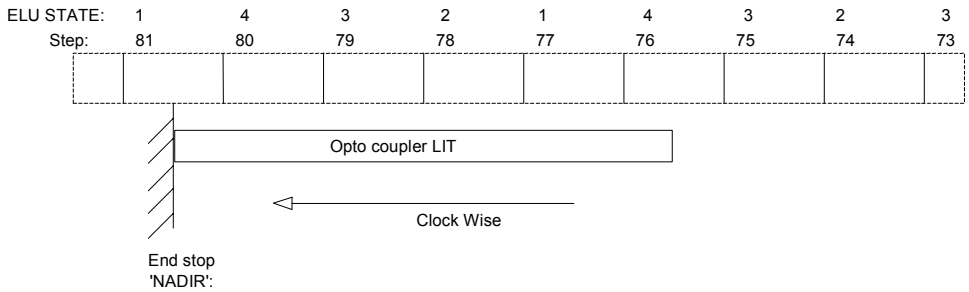
FMM anomaly: overview

- On **Feb 28th** at 00:23:18 GMT OMI stopped generating science data due to a FMM anomaly.
- Investigation started immediately after the occurrence of the anomaly.
  Parties involved:
  - Instrument Operations Team
  - Industry (Dutch Space and TNO-TPD)
  - NASA / AURA Flight Operations Team
  Decisions were formalized by means of Non-Conformance Review Boards.
- OMI resumed generating science data on **March 3rd** (only earth and dark measurements, no calibration measurements).
- As part of the anomaly investigation 13 FMM tests were carried out in the period March 8th – May 17th.
- Although the FMM tests provided detailed information on the in-flight FMM behaviour, the FMM behaved nominally during all tests and no root cause could be found for the anomaly.
- On **June 12th** OMI resumed full nominal operations generating earth science data as well as calibration data.

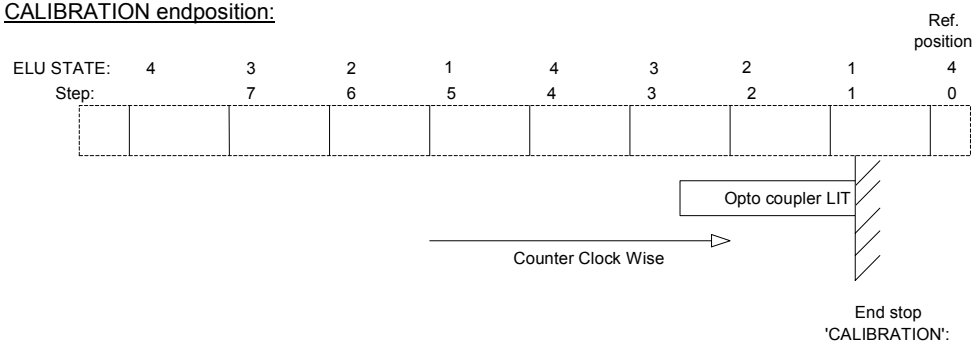
FMM anomaly: operating the FMM

Folding Mirror Mechanism:

NADIR endposition:



CALIBRATION endposition:



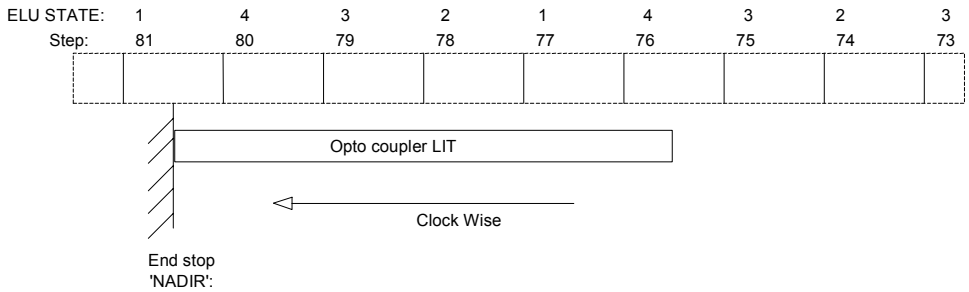
- For calibration measurements:
  - assume an unknown initial FMM position.
  - move the FMM from this unknown position to calibration position 0 by commanding 85 steps.
  - in case the FMM bounces against the endstop, indicated by a dark status of the opto-coupler, move the FMM 4 additional steps from position 4 to position 0.
  - when the calibration measurement is finished, move the FMM to the nadir position 79.

- For nadir (earth) measurements:
  - not needed to move the FMM, because the default position is the nadir position.

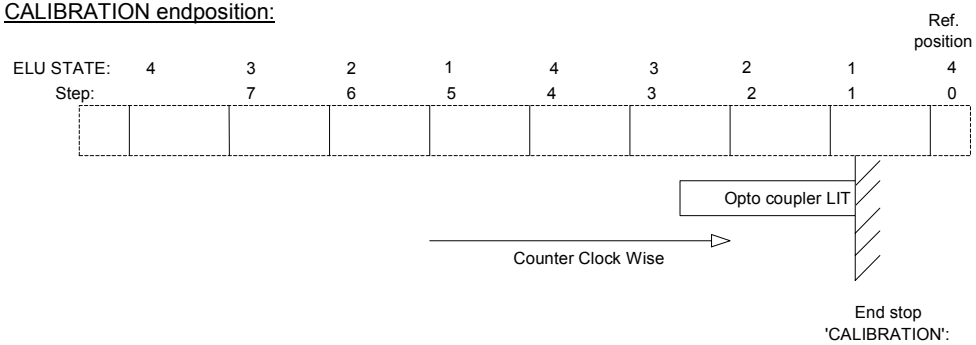
FMM anomaly: what went wrong?

Folding Mirror Mechanism:

NADIR endposition:



CALIBRATION endposition:

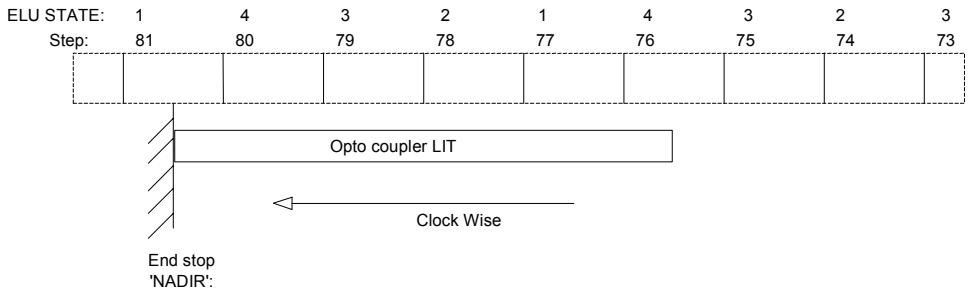


- Till Feb 19th the FMM always bounced against the calibration endstop when moving to the calibration position.
- Between Feb 19th and Feb 28th the FMM not always bounced.
- On Feb 28th, when moving the FMM into calibration position for a LED calibration measurement, the opto-coupler status remained “dark” even after the 4 additional steps.
- Automatically a Fault Management procedure started, resulting in a transition to Idle mode which effectively stopped the generation of science data.
- As part of the Fault Management procedure, the FMM was moved to nadir position.

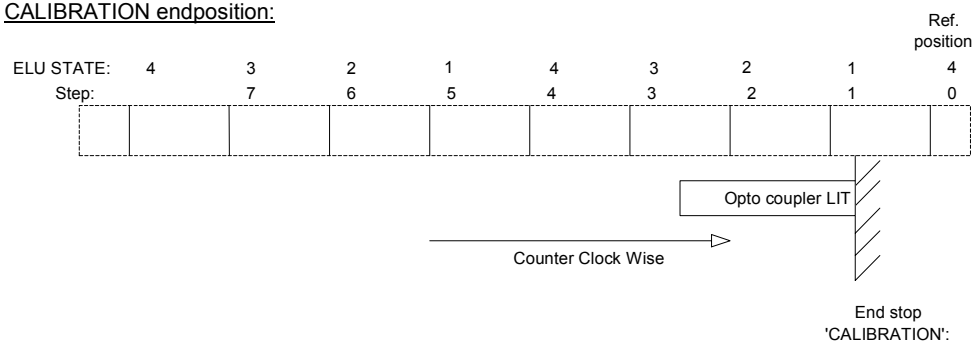
FMM anomaly: telemetry analysis

Folding Mirror Mechanism:

NADIR endposition:



CALIBRATION endposition:

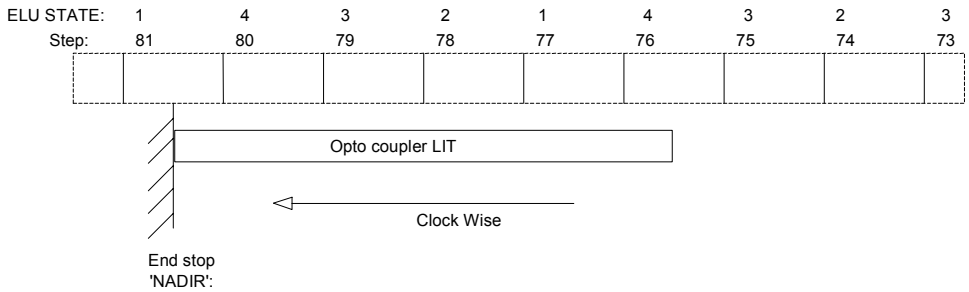


- Telemetry analysis showed that the FMM, as part of the Fault Management procedure, was indeed moved to nadir position.
- This was confirmed when, after March 3rd, earth images became available again which showed that the optical path was not blocked by the FMM.

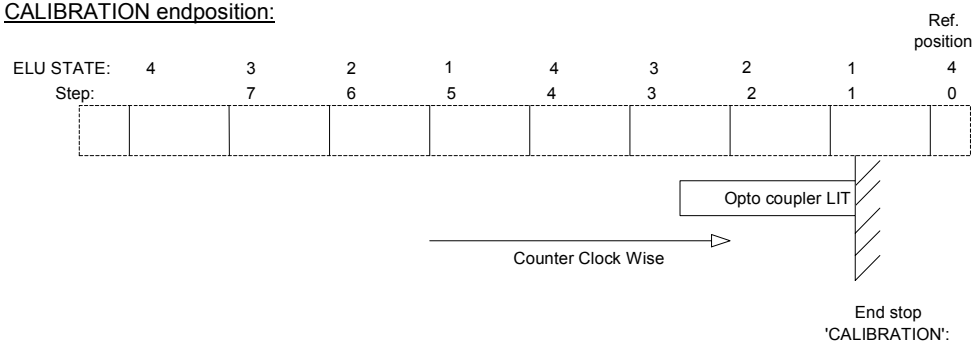
FMM anomaly: testing the FMM

Folding Mirror Mechanism:

NADIR endposition:



CALIBRATION endposition:



Purpose of various tests:

- **Tests 1-3**:
  Find out if the FMM can be moved around its nadir position?
- **Tests 4-5**:
  Find out if the redundant FMM coils can be used, also in combination with the nominal FMM coils (double drive torque!)
- **Tests 6-8**:
  Find out if the FMM can be moved from the nadir position 79 to position 2 without loosing steps in between due to mechanical/electrical wear.
- **Tests 9-10**:
  Find out if there is mechanical/electrical wear or opto-coupler problem at position 1.
- **Tests 11 (without WLS) – 12 (with WLS)**:
  Find out if there is mechanical/electrical wear or opto-coupler problem at position 0; find out if bouncing is taking place.
- **Test 13 (with WLS)**:
  Find out the precise position of the calibration endstop by commanding FMM to virtual position -4; find out when FMM jumps back.

FMM anomaly: test results

- All tests were successful.
- During all tests the FMM showed nominal behaviour.
- There is no loss of steps when moving the FMM from nadir position to calibration position and vice versa.
- There is no indication for an opto-coupler problem.
- No bouncing against the calibration endstop takes place when commanding the FMM step-by-step.
- When using the WLS, the WLS signal is highest at FMM position 1 whereas position 0 (the calibration position) was expected.
- It turns out that the FMM position during a calibration measurement is just in front of the calibration endstop and not at the calibration endstop.
- A known initial position 79 can be assumed when starting to use the FMM.

FMM anomaly: cause and corrective action

Cause:

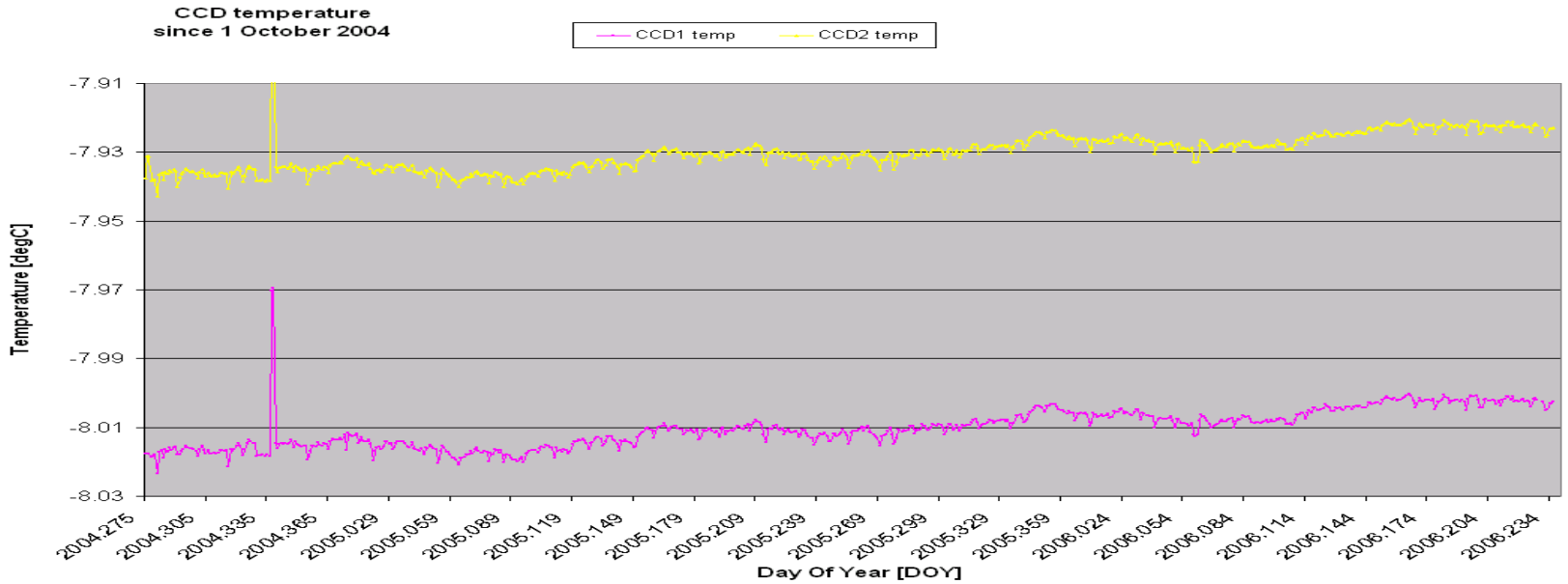
- Despite all the successful tests, the root cause for the FMM anomaly has not been found.
- One possible cause (although it cannot be proven) is that, instead with the usual 4 steps, the FMM bounced 8 steps when moving to the calibration position. This has occurred only once during an on-ground test.

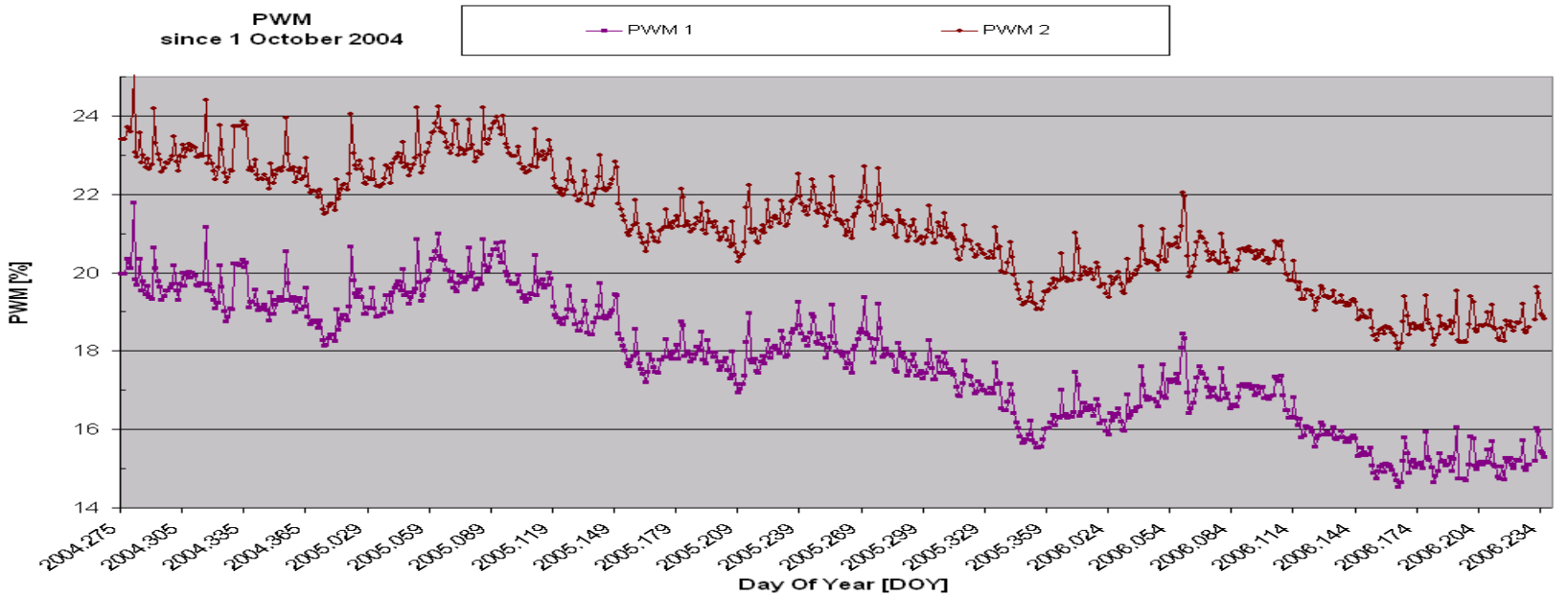
Corrective action:

- A relation is assumed between the changing bouncing behaviour as observed between Feb 19th and Feb 28th and the FMM anomaly on Feb 28th.
- By operating the FMM in a different way, bouncing against the calibration endstop can be avoided.
- All calibration measurements are performed by means of Stored Instruction Sequences (SISs). All SISs that use the FMM will be modified to avoid bouncing.
- In the next coming months old SISs will be replaced by new SISs.
- Replacing the old SISs by the new SISs will have no impact on the measurement schedule.
- The FMM is now continuously monitored by automated TM checking

Operations Status and Outlook

- OMI performs nominal
- OMI is taking both earth and calibration measurements according to the (unchanged) Nominal Operations Baseline.
- On June 17th a new LED linearity measurement was performed for the first time giving more detailed information on the non-linear relation ship between the incoming flux on the CCD and the resulting number of electrons in the CCD read-out register.
- All calibration SISs that use the FMM will be updated to avoid bouncing of the FMM.
- 29 new orbit-type activities have been developed that enable a more flexible timing of the earth measurements during the ozone hole season. This is to avoid CCD saturation in the UV spectral region.
- Except for the FMM anomaly there have been no other instrument anomalies.
- OMI is thermally still very stable. No change of thermal settings needed.


CCD temperature
since 1 October 2004
CCD1 temp
CCD2 temp
Temperature [degC]
-7.91
-7.93
-7.95
-7.97
-7.99
-8.01
-8.03
2004.275
2004.305
2004.335
2004.365
2005.029
2005.059
2005.089
2005.119
2005.149
2005.179
2005.209
2005.239
2005.269
2005.299
2005.329
2005.359
2006.024
2006.054
2006.084
2006.114
2006.144
2006.174
2006.204
2006.234
Day Of Year [DOY]


PWM
since 1 October 2004
PWM 1
PWM 2
PWM [%]
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22
20
18
16
14
2004.275
2004.305
2004.335
2004.365
2005.029
2005.059
2005.089
2005.119
2005.149
2005.179
2005.209
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2006.144
2006.174
2006.204
2006.234
Day Of Year [DOY]

Current OMIS IOT team members

KNMI

Jacques Claas

Mirna van Hoek

Dutch Space

Leo van Lent

Northrop Grumman

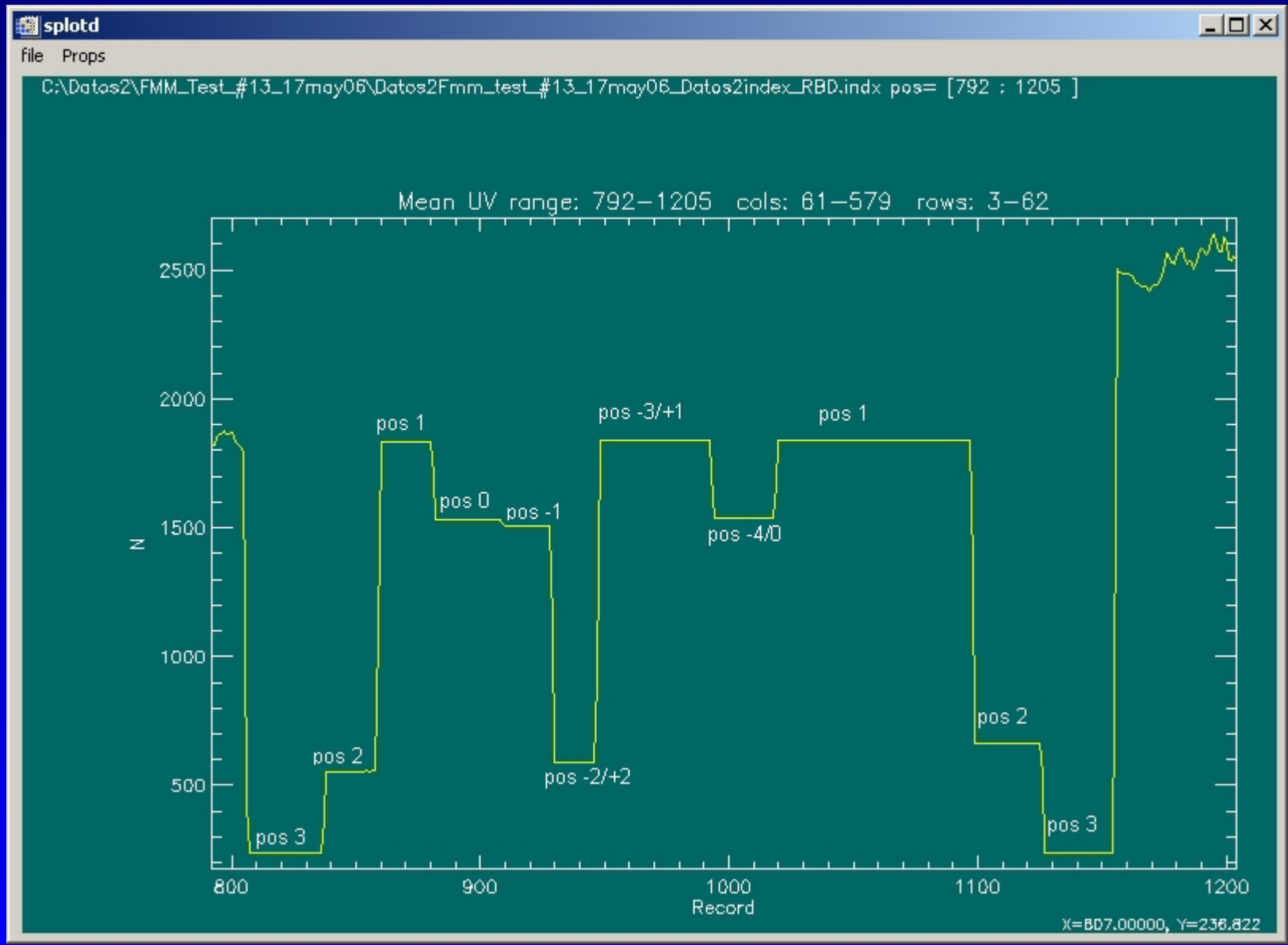
Ayman Mekhail

Available 24/7

AURA-FOT

Joe Purcell

Position calibration end-stop (result from FMM test #13)



Ozone Hole 2006
Aug 21 – Sep 9